CHAPTER

2

PLANNING FOR SERVER HARDWARE

After reading this chapter and completing the exercises you will be able to:

- Explain the hardware requirements for Windows 2000 Server
- Explain the importance of using Microsoft's hardware compatibility list
- Determine specifications for your server in terms of the right processor type, bus type, and advanced bus features
- Select the right network interface card (NIC) for your server
- Calculate the amount of memory needed for your server
- Plan disk capacity, disk architecture, and fault tolerance
- Plan a backup system and CD-ROM specifications

The server hardware provides an essential foundation for building a Windows 2000 server, because you can only fully take advantage of the operating system's capabilities when the hardware meets operating system specifications. At one time, network server operating systems were rudimentary and could not take advantage of all the features available even in basic personal computers. That situation has changed dramatically as server hardware manufacturers now struggle to keep up with the new capabilities built into server operating systems, with Windows 2000 Server as a prime example. Windows 2000 Server is capable of implementing advanced features that make it possible to outfit a server for high-speed networking, sophisticated disk storage, and multiple-processor computing. With features like these, a server that fits on your desktop can rival a mainframe computer that occupies the space of a small house.

In this chapter, you look at the vital elements required to fully outfit a server for different kinds of situations. You begin by looking at the minimum hardware requirements for Windows 2000 Server and the different processor options, which include Pentium and Pentium Xeon. You learn about bus architectures and new options such as the I_2O architecture and server clustering. Two other important areas are the selection of the right NIC for your server and choosing the proper amount of memory. Server storage, tape backup capabilities, and CD-ROM drives will be discussed last to round out your journey in outfitting a server. The discussion in each area is focused on helping you determine the right fit for the smallest to the largest implementations.

System Requirements

The most basic step in selecting a server is to review the minimum system requirements for Microsoft Windows 2000 Server. In the past, the requirements for Windows NT Server and Windows NT Workstation have been very similar, but that is not the case with Windows 2000 Server and Windows 2000 Professional. Windows 2000 Server includes many more service options and more robust connectivity, which means it requires more resources than Windows 2000 Professional does—which is not surprising because one is a server network operating system, and the other is a client/workstation network operating system. Tables 2-1 and 2-2 give the minimum requirements for Intel and RISC-based computers for Windows 2000 Server and Windows 2000 Professional, respectively.

Keep in mind that these are *minimum* requirements for installation. Additional hard disk space is required for application and data files, and additional memory may be required for some applications and to increase performance. To maintain backward compatibility so you do not lose your current investment in hardware, Microsoft has worked to keep down the minimum CPU requirements, stressing RAM and hard disk resources instead.

With these requirements in mind, you need to plan hardware that exceeds the minimums to accommodate the clients that will access the server, extra software besides the operating system, and data stored on the server. You will need to plan a server with enough CPU horsepower, disk storage, RAM, and backup resources for a system fully loaded to match the intended use and positioned to grow as your organization grows.

Table 2-1 Minimum Hardware Requirements to Install Windows 2000 Server

Component	Intel-type Computer Requirements
Processor	Pentium 166 MHz or faster
Display	VGA or better
Memory (RAM)	64 MB for five or fewer clients and 128 MB for larger networks
Hard disk space	685 MB for system files (2 GB recommended)
Floppy disk drive	High-density 3.5-inch
CD-ROM drive	Required for installations not performed over the network (12X or faster)
Network interface card (NIC)	Required to connect to the network
Mouse or pointing device and keyboard	Required

Table 2-2 Minimum Hardware Requirements to Install Windows 2000 Professional

Component	Intel-type Computer Requirements
Processor	486 MHz or faster (Pentium recommended for better performance)
Display	VGA or better
Memory (RAM)	32 MB (64 MB is recommended for better performance)
Hard disk space	500 MB for system files (1 GB recommended for better performance)
Floppy disk drive	High-density 3.5-inch
CD-ROM drive	Required for installations not performed over the network (12X or faster)
Network interface card (NIC)	Required to connect to the network
Mouse or pointing device and keyboard	Required

Windows 2000 Server Compatibility

Your first stop in selecting hardware should be to check Microsoft's **hardware compatibility list** (**HCL**) for Windows 2000 Server, a document that comes with the Windows 2000 Server software and is located in the \Support folder on the Windows 2000 Server CD-ROM. The most up-to-date version is available on the Microsoft Web site, *http://www.microsoft.com/*. (You can practice accessing the HCL in Hands-on Project 2-1).

Microsoft reviews all types of hardware to determine whether they will work with Windows 2000 Server and other Microsoft operating systems, Windows 2000 Professional

and Windows 98, for example. There is an HCL for each operating system, which includes information on the following hardware:

- Single-processor computers
- Multiprocessor computers
- Processor upgrades
- PCMCIA hardware
- SCSI adapters and drives
- Video adapters
- Network adapters
- Audio adapters
- Modems
- Printers
- Tape devices
- Uninterruptible power supplies (UPSs)

The best steps you can take to avoid Windows 2000 Server installation difficulties are to select well-known brand names from the HCL and to avoid hardware from small companies that build individual computers from generic parts. Most established computer manufacturers have products compatible with Windows 2000 Server, although their prices may be somewhat higher than those of the smaller companies. Cutting expenses when buying server hardware could prove to be costly later on if it results in unreliable equipment and difficult software installations.

CPU Sizing

Most Intel-based servers sold as of this writing are Pentium III and Pentium III Xeon computers with a CPU clock speed of 500 megahertz (MHz) or faster. The **clock speed** is the rate at which the CPU sends data through the **buses**, or data pathways, inside the computer. A high clock speed helps ensure the CPU does not become bottlenecked with more processing requests than it can handle. Buses come in different capacities, measured in terms of bits. For example, Pentium computers can send data in 32-bit streams. A typical character, such as the letter *r* or the number *5*, is packaged as 8 bits (1 byte). Thus, a 32-bit bus can carry 4 characters in each clock cycle.

At this writing, Intel is completing work on a new 64-bit processor called Merced, which is likely to displace the Xeon processor in server applications that require a powerful CPU, such as in heavily used Web sites and client/server computing.

Pentium Computers

Windows 2000 Server will work using an Intel-based Pentium with a 166 MHz or higher clock speed. Many organizations have implemented small Pentium servers, 166–233 MHz for example, with positive results. But the limitations of a smaller Pentium computer become apparent as the server demand grows. The slower clock speed puts these servers at a disadvantage compared to Pentium-II- or Pentium-III-based computers.

Windows 2000 Server takes advantage of the Pentium's fast clock speeds and 32-bit bus to provide better server response. Windows 2000 also uses Pentium-enabled features such as multithreading and multitasking (see Chapter 1). A high clock speed is recommended

because this increases the speed at which the computer can internally transfer data, such as between the CPU and a disk or tape drive.

Another important factor is processor caching. Processors use specifically allocated workspaces, called registers, to complete tasks. One way to increase the speed at which the processor works is by providing extra storage space on a chip, so that processor operations and instructions can be queued and quickly swapped in and out of the processor's registers. The extra storage is called **processor cache**. A processor uses two levels of cache. Level 1 (L1) cache is built into every processor, but is very small, at 8 KB to 64 KB. Level 2 (L2) cache is a technique for implementing more processor cache in addition to L1, but is often slower, depending on the design. The basic Pentium processor uses a static RAM (SRAM) chip for L2 cache that is plugged into a socket or directly soldered into the main board.

Whereas the Pentium processor uses an SRAM chip plugged into the main board for cache, the Pentium Pro processor integrates cache on the same chip as the processor. The L2 cache built into the Pentium Pro chip is either 256 KB, 512 KB, or 1 MB, with 512 KB as the most common implementation.

L2 caching architecture has been changed in the Pentium II and Pentium III processors by placing processor cache on a separate "daughter" board that attaches to the main computer board. This architecture is less expensive than the Pentium Pro, but not as fast. Pentium II and Pentium III caching, however, is faster than the early Pentium and SRAM chip combination, because access to the daughter board is designed to be faster than access to an SRAM chip plugged into the main board. Besides L2 caching, another difference introduced with the Pentium II is a faster external operating bus speed than is used in the Pentium and Pentium Pro computers.

There are differences between the Pentium II and the Pentium III: The Pentium II processors have been manufactured at 350, 400, and 450 MHz, while Pentium III processors are over 500 MHz. The Pentium III also includes special support for faster Web caching and better TCP/IP performance.

Intel's Celeron processor is an option intended for users who want a processor that costs less than a Pentium. One way in which the cost is reduced is that the Celeron does not implement L2 caching. For this reason, the Celeron and similar processors made by other manufacturers are not recommended for Windows 2000 Server.

Pentium II and Pentium III computers can be purchased with the Xeon architecture, which employs an L2 daughter board caching technique that is over twice as fast as a non-Xeon. Xeon processors are usually sold with 512 KB of L2 cache that can be expanded to over 1 MB. At this writing, a Pentium III Xeon processor is typically two to four times the cost of a non-Xeon Pentium III. Server applications that benefit from fast L2 cache, such as busy Web servers, are one place in which Xeons are used.

Component	Intel-type Computer Requirements
Processor	Pentium 166 MHz or faster
Display	VGA or better
Memory (RAM)	64 MB for five or fewer clients and 128 MB for larger networks
Hard disk space	685 MB for system files (2 GB recommended)
Floppy disk drive	High-density 3.5-inch
CD-ROM drive	Required for installations not performed over the network (12X or faster)

Multiprocessor Computers

Windows 2000 Server is designed to fully exploit the capabilities of multiprocessor computers. Many computer vendors make Pentium-based multiprocessor computers to be used specifically as servers. These **symmetric multiprocessor** (**SMP**) computers have two, three, four, eight, or more processors to share the processing load.

If you purchase an SMP computer, make sure you understand the requirements for adding CPUs. Some use an architecture that requires CPUs to be added in multiple numbers, such as in pairs, making CPU upgrades expensive.

Clustering Computers

Clustered computers are computers that operate together as one shared resource. They are linked together by two elements: the operating system, such as Windows 2000, and high-speed links between the computers, such as 100 megabits per second Fast Ethernet. To the user or server manager who logs onto the cluster, the computers appear as one server. A cluster is often composed of identical types of computers, all Intel-based SMP computers, for example. Clustered computers are frequently used to provide uninterrupted service when one computer fails and to provide a means to expand processing power, storage, and RAM when an existing system is heavily overloaded.

Microsoft defines two models for clustering: shared disk and shared nothing. The **shared disk model** is one in which all servers equally share resources that include disks, CD-ROM, and tape storage (Figure 2-1). The **shared nothing model** is one in which each server owns and accesses a particular resource, a disk drive, for example (Figure 2-2). In the shared nothing model, if one computer fails, the resources that it owns can be taken over by a different computer in the cluster that is still operational.

At this writing, clustering is supported in Windows 2000 Advanced Server and Windows 2000 Datacenter. The shared disk model is supported in the framework of what Microsoft calls a failover solution. In this solution, two servers share disk resources and if one server fails, the other clustered server fills the gap. Microsoft's goal in the near future is to implement a second sharing option, called the multiple node solution. In this solution, up to 16 servers can be added to a cluster, with the Windows 2000 operating system allocating CPU load equally among the clustered servers on the basis of current need.

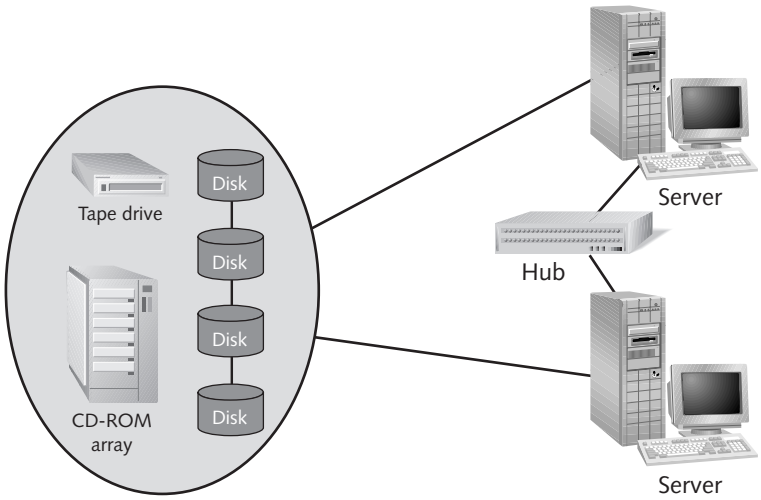

Figure 2-1 Shared disk clustering model

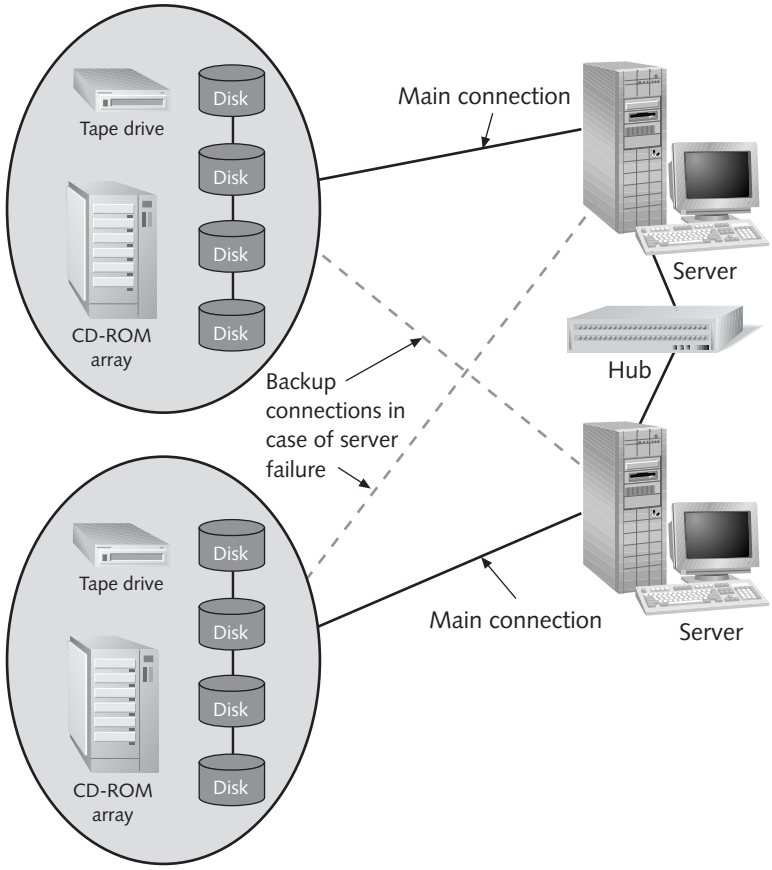

Figure 2-2 Shared nothing clustering model

BUS ARCHITECTURES

Computers have two buses. The internal bus carries instructions about computer operations to the CPU. The external bus carries data to be processed, such as for mathematical operations. The server's speed is influenced by the size of the bus. Pentium servers have a 32-bit bus (with the exception of the Merced processor, which is 64-bit) and RISC servers have a 64-bit bus.

Windows 2000 Server is a 32-bit operating system, which means it can take advantage of a 32-bit or larger bus design. With this in mind, Windows 2000 supports the following bus types:

- **Industry Standard Architecture** (**ISA**): 8-bit and 16-bit bus architecture dating to the early 1980s
- **Extended Industry Standard Architecture** (**EISA**): 32-bit bus built on the ISA architecture with faster throughput by means of **bus mastering**, which enables some processing activities to take place on interface card processors instead of on the CPU
- **Micro Channel Architecture** (**MCA**): 32-bit bus proprietary to IBM computers and having a slightly faster transfer rate than EISA
- **Peripheral Computer Interface** (**PCI**): 32-bit and 64-bit bus with the fastest data transfer rate and local bus capability

Modern servers contain primarily PCI buses for fast transport of information via heavily used components such as disk drives and NICs. They also contain a few ISA or EISA buses for backward compatibility with older components (try Hands-on Project 2-2, which uses the Add/Remove Hardware Wizard to view the buses set up on your computer).

I_2O ARCHITECTURE

Intelligent input/output (**I_2O**) architecture is a communications architecture that is new to network servers, although it has been used for years in mainframe computers. I_2O removes some of the I/O processing activities from the main processor to I_2O processors on peripherals designed for I_2O architectures, such as hard disks. I_2O also involves using one general device driver for all I_2O-compliant devices, instead of a separate device driver for each manufacturer's device that uses I_2O. The purpose of I_2O is to increase the speed of operations involving peripherals, while reducing the need for the main processor to handle I/O processes. A driver is software that allows a computer to communicate with devices such as hard disks, printers, monitors, and network interface cards.

I_2O involves two software components: the OS Services Module and the Hardware Device Module (Figure 2-3). The OS Services Module is software that is linked into the Windows 2000 Server operating system to interact with the kernel. The Hardware Device Module is software located on the peripheral controller or adapter that operates independently of the operating system. Communication between the OS Services Module and the Hardware Device Module is accomplished through protocols designed for the I_2O architecture. Windows 2000 Server supports I_2O.

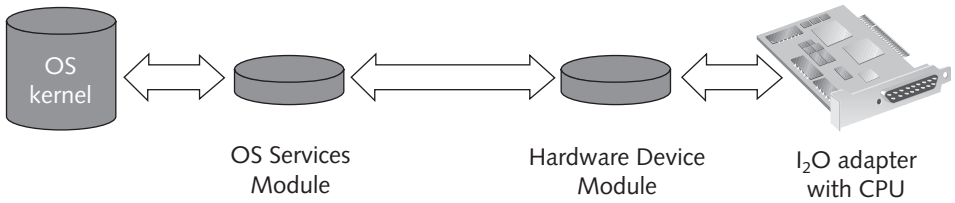

Figure 2-3 I_2O communications architecture

PLUG AND PLAY

One important advance in computer hardware and operating system software is the ability to automatically detect and configure new hardware devices, such as in the addition of a disk or tape drive. This ability is called **Plug and Play** (**PnP**) and must be:

- Built into the device in the computer
- Enabled in the computer's basic input output system (BIOS)
- Built into the computer's operating system kernel

Windows 2000 has even better PnP support than Windows 95 or Windows 98, a feature that was lacking in the previous versions of Windows NT. As you configure hardware, choose a server that has a BIOS that can interface with the Windows 2000 PnP capability. Also, when you add hardware to a server, a NIC for example, purchase one that is PnP-compatible. PnP can help you easily install hardware without struggling to configure it and without conflicts with other devices that use the computer's internal hardware and memory resources. One way to determine if the computer's BIOS supports PnP is to check the documentation for that computer and then verify the capability in the computer's BIOS setup options, as shown in Hands-on Project 2-3.

USB

As you plan the server hardware, plan to purchase a computer that has a **universal serial bus** (**USB**) and external ports. A USB is a relatively new bus standard that improves on the concept of serial and parallel communications, such as the EIA/TIA-232 (formerly RS-232) serial communications approach. When your computer has a USB, you can plug in devices without powering off the computer. USB supports up to 127 separate devices on a single port, including pointing devices, CD-ROM drives, tape drives, cameras, scanners, telephones, and audio equipment. The USB implementation in Windows 2000 also supports PnP, so that each new device is automatically detected when it is installed. The data transfer rate of a USB can be up to 12 Mbps.

CHOOSING NICS

A **network interface card** (NIC) is used to enable a network device, such as a computer or network equipment, to connect to a network. The network connection provided through a NIC involves four components:

- An appropriate connector for the network medium
- A transceiver
- A controller to support media access control (MAC) protocol communications and addressing (see Chapter 3)
- Protocol control firmware

The connector and its associated circuits are designed for a specific type of medium, such as coax, twisted-pair, or fiber-optic cable. Some combination NICs are made with multiple 1.1 connectors so they can be used with different media, such as combination coax and twisted-pair NICs, which are the most common examples of this option. When a combination NIC is used, it comes with software drivers or firmware to match the media options. **Firmware** is software that is stored on a chip, such as a ROM. Also, some NIC drivers are able to detect the medium attached to the NIC and then automatically set up the correct driver for the medium. (Try Hands-on Project 2-4 to find the location of a NIC driver in Windows 2000.)

The cable connector is attached to the transceiver, which may be external to the NIC or built into it. For most computers, servers, and network equipment, the transceiver is built into the interface card.

The MAC controller unit and the firmware work together to correctly encapsulate network source and destination address information, the data to be transported, and error-detection information into frames sent out to the network.

For a typical network, purchase a NIC that can transmit at either 10 Mbps or 100 Mbps. On a heavily loaded network or for a server that is used for multimedia, consider using a high-speed 1-Gbps (gigabit per second) NIC (if your network equipment supports 1 Gbps). Also, many NICs are able to handle both half duplex and full duplex transmissions. **Half duplex** means that the NIC and network equipment are set up so they cannot send and receive at the same time. **Full duplex** is the capacity to send and receive simultaneously (which is possible because of buffering at the NIC). Choose a NIC that can be set for half duplex or full duplex, so you have flexibility. Figure 2-4 illustrates a NIC set in full duplex mode. (Try Hands-on Project 2-5 to learn about duplex and other NIC settings.)

A NIC is customized for a specific type of bus, such as EISA or PCI. When you develop specifications for a server, as mentioned earlier, plan to purchase one with PCI expansion slots and a 32-bit PCI NIC. A NIC with fast throughput is critical to your server.

Purchase a NIC from a brand-name vendor in the Microsoft HCL. If the NIC is preinstalled in the computer, make sure in advance that it is compatible with Windows 2000 and the type of network in which the server will be used, such as Ethernet or token ring.

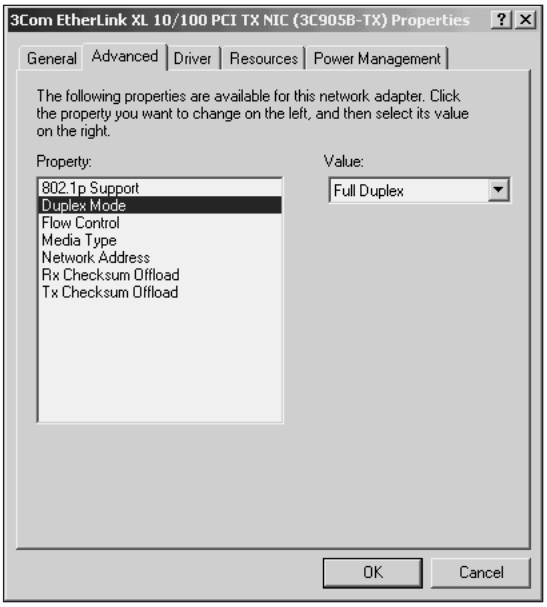

Figure 2-4 NIC Duplex Mode setting

Although Microsoft Windows 2000 Server includes drivers for many brands of NICs, make sure you obtain the most recent driver from the NIC manufacturer. Enhancements are made to NICs for which the latest driver is necessary. Also, an old NIC driver may contain software "bugs" that are corrected by a newer version. Most NIC vendors provide regular updates to their drivers to ensure against transmission problems, and many distribute these updates through the Internet (try Hands-on Project 2-6). The ability to receive frequent updates from a quick, online source is very important, because network drivers are historically problematic.

Memory Sizing

Another factor that influences how well a server performs is the amount of memory available to the server. Table 2-3 shows memory guidelines for different versions of Windows 2000 Server on Intel-based computers.

Table 2-3 Memory Guidelines

Operating system	Processor type	Memory
Windows 2000 Server for five or fewer users	Intel	64 MB
Windows 2000 Server for over five users	Intel	128 MB to 4GB
Windows 2000 Advanced Server	Intel	128 MB to 64 GB
Windows 2000 Datacenter	Intel	128 MB to 64 GB

Microsoft recommends a minimum of 128 MB on all versions of Windows 2000 Server, however, they also recommend that you use at least 256 MB or more for best performance.

Memory is one of the most critical components of a server. An inexpensive way to boost server performance is to install extra RAM. Estimating the amount of RAM needed is not an exact science, but some basic rules still apply. First, start at the minimum amount of memory needed for the operating system kernel (64 MB). Next, determine the number of people who will be accessing the system at the same time and the memory requirements of server software that runs all of the time. Finally, determine the average software requests per user and the amount of memory required for the requests. For example, consider a system with 100 maximum simultaneous users who need an average of 2 MB per connection to access word-processing, spreadsheet, and program files. Also, assume that you are running Domain Name Service (DNS), Windows Internet Naming Service (WINs), and Simple Network Management Protocol (SNMP) services that require 2.3 MB, 2.7 MB, and 2.7 MB, respectively. (These protocols are discussed in Chapter 3.) The calculation of memory is as follows:

64 MB for the operating system + (100 users * 2 MB average memory use) + (7.7 MB for DNS, WINs, and SNMP) = 271.7 MB of memory

You can use the Windows 2000 Task Manager to determine the amount of memory used by a process, such as the DNS server process, Dns.exe. (Try Hands-on Project 2-7 to determine the amount of memory that is used by a process.)

In this case, you want at least 272 MB of memory and will likely want to allow for growth by adding an extra margin of 32–64 MB for a total of over 304 MB. The exact amount, of course, will depend on the memory chip combinations that the computer will allow, as determined by its manufactured specifications. Also, when purchasing memory, it is safest to purchase **error checking and correcting** (**ECC**) memory chips. That type of chip keeps some memory in reserve for when problems occur. It also makes an automatic correction if a parity error is detected, preventing the file server from crashing in the event of a memory parity error.

Disk Storage

Choosing the right hard disk drive is just as important as selecting the right bus. Hard disk access on a file server is far more frequent than on a typical workstation. This constant activity leads to congested data paths and the malfunctioning of overused disk drive parts. In choosing a server hard drive, you will need to make decisions about capacity, contention, and fault tolerance.

Disk Capacity

Estimating hard disk capacity is based on calculating space for the following:

- Operating system files
- Software files
- Data and database files
- User files
- General public files
- Utility files
- Server management files

Most server administrators calculate a general figure based on the total number of bytes needed. Table 2-4 illustrates how the number of bytes might be calculated for a law office consisting of 22 users.

Table 2-4 Calculating Disk Capacity

Operating System Files	Estimated Size
Microsoft 2000 Server (depending on the accessories and services installed)	685 MB
Subtotal	685 MB
Application Software	**Estimated Size**
Microsoft Office	150 MB
Microsoft Exchange	150 MB
Paradox database software	70 MB
Accounting software	250 MB
Legal time-accounting software	200 MB
Client databases	275 MB
Court forms	52 MB
Contracts forms	42 MB
Tax law forms	41 MB
Will legal forms	45 MB
Bankruptcy legal forms	35 MB
Database query software	72 MB
Subtotal	1382 MB
User Directories	**Estimated Size**
Each user 100 MB * 22	2200 MB
Subtotal	2200 MB

Table 2-4 Calculating Disk Capacity (continued)

Public Directories	Estimated Size
Shared directories containing word-processing files, spreadsheets, and data	590 MB
Utility directories	50 MB
Subtotal	640 MB
Server Management Software	**Estimated Size**
Extra utilities for server and network management	175 MB
Subtotal	175 MB
Total	**5082 MB**

Table 2-4 shows a total of 5.082 GB required in estimated disk space. An additional amount should be added to accommodate anticipated growth such as extra space needed by users and for new software that will be installed. Also, in this situation the law firm should take into account expected growth in the databases, accounting data, and legal time-accounting software. Each time the firm bills a client or records information about a new client, data in these areas will grow. Also, some users may need larger allocations for user directories. A margin of growth in this situation might be calculated at 50 percent for the next two years. Adjusting the capacity requirements for growth yields the following estimate:

$$5.082 \text{ GB} + (5.082 \text{ GB} \times 0.5) = 7.623 \text{ GB}$$

Disk Contention

Disk contention is the number of simultaneous requests to read or write data from or to a disk. The number of requests processed by a server can be quite large when there are many users, such as 100 or more. Disk contention can be reduced through the design of the server disk storage. The primary design issues are:

- Speed of the individual disks
- Speed of the disk controllers
- Speed of the data pathway to the disks
- Number of disk pathways
- Disk caching

The speed of the disk is called **disk access time**, measured in milliseconds (ms). This is the time it takes for the read/write heads on the disk to reach the data for reads or updates. A fast disk access time can reduce disk contention. Disk drives manufactured today have fast access times of 10 ms or less. Access time is important, but because most disks are built to be fast, it is not as important as how quickly the data reaches the disk.

The speed of the data pathway or channel is called the **data transfer rate**, and is measured in megabytes per second (Mbps), ranging from about 16.6 Mbps to about 1 Gbps. The data

transfer rate is determined by the type of disk controller used in the server and the data pathway. The disk controller is the board that acts as the interface between the disk drives and the computer. Figure 2-5 shows a disk controller. Many computer systems come with **Integrated Device Electronics** (**IDE**) or **Enhanced Small Device Interface** (**ESDI**) disk controllers. These controllers provide average data transfer rates and traditionally have been a viable choice for older servers.

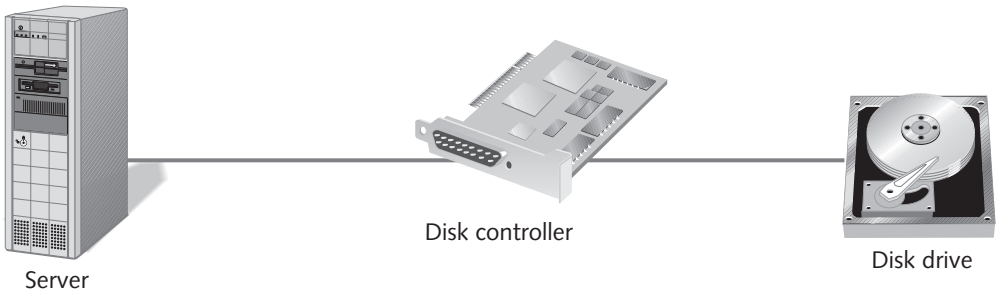

Figure 2-5 Disk controller connecting a disk drive

One good choice for a modern server is to implement a **Small Computer System Interface** (**SCSI**), which takes advantage of the 32-bit bus architecture of Pentium computers. SCSI interfaces rely less on the main system CPU than IDE and ESDI controllers do, freeing the CPU for other work. Data transfer rate enhancements continue to be implemented for SCSI devices. The standard SCSI-1 interface has a data transfer rate of 5 MBps, which is many times that of IDE or ESDI. The second generation SCSI-2 interfaces come with narrow and wide bus options. The wide interfaces have about twice the data transfer speed, 20 MBps, as the narrow ones, at 10 MBps. Today Ultra SCSI and wide Ultra SCSI adapters are used on Pentium-based servers because they transfer data at 20 MBps and 40 MBps, respectively. Some servers are equipped with Ultra2 SCSI adapters that are relatively new on the market, offering 80 MBps data transfer. SCSI-3 adapters are made for **Reduced Instruction Set Computers** (**RISC**) computers and have speeds up to 100 MBps. RISCs have CPUs that require fewer instructions for typical operations, which enables their processors to work faster. Table 2-5 summarizes the SCSI interface speeds.

Wide Ultra SCSI adapters for Intel-based computers are called SCSI-3 by some manufacturers.

Several disk drives or other devices, such as a tape drive or CD-ROM drive, can be daisy-chained on the cable of a SCSI adapter. Wide Ultra SCSI or Ultra2 SCSI provides the best performance when devices are daisy-chained. Also, it is important to make sure each device connected to the interface has a unique address, with the first device addressed as 0. Problems occur if two devices have the same address. The SCSI cable must be terminated with a SCSI terminator at the last device that is connected.

Table 2-5 SCSI Interface Data Transfer Rates

Interface	Data Transfer Rate
SCSI-1	Up to 5 MBps
Narrow SCSI-2	Up to 10 MBps
Wide SCSI-2	Up to 20 MBps
Ultra SCSI	Up to 20 MBps
Wide Ultra SCSI	Up to 40 MBps
Ultra2 SCSI	Up to 80 MBps
SCSI-3 (RISC)	Up to 100 MBps

Omitting the cable terminator is a common cause of problems when connecting several devices to one SCSI adapter. If you experience difficulty recognizing hard disk storage during the Windows 2000 Server installation, check to make sure that the terminator is connected to the last device on the SCSI cable.

Computers designed as servers generally come equipped with SCSI-2 adapters or higher. Watch for new developments with SCSI adapters, particularly in extending data transfer rates over 100 MBps for Pentium-based computers.

The controller of a SCSI device is directly attached to the device. This design makes it possible to mix different devices on the same interface. The SCSI interface plugs into one of the computer's open expansion slots on the main board. A cable is run in daisy-chain fashion from the adapter to the controller card for each device, with a terminator at the last device. Several disk drives, a tape drive, and other SCSI devices can be attached to one adapter, as shown in Figure 2-6.

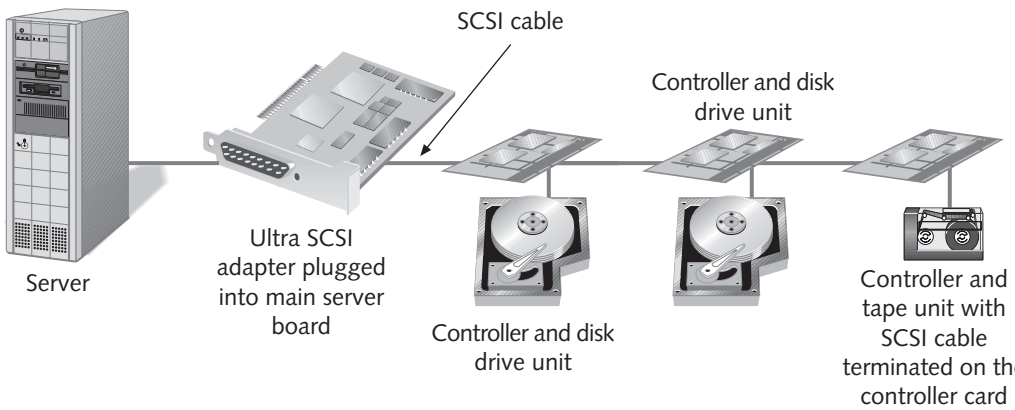

Figure 2-6 Ultra SCSI adapter connected to two disk drives and a tape drive

When you configure a server, be cautious about placing too much demand on access to hard disk storage. If you purchase only one drive, all the users will contend for data on that drive.

If you purchase two drives to place on one SCSI adapter, the data contention on the single pathway may be excessive. One solution is to purchase a server with an Ultra SCSI or Ultra2 SCSI interface and put both drives on the same pathway. A better solution is to create two separate pathways with two adapters, as shown in Figure 2-7 (a technique that can also be used for attaching RAID drives, which are discussed later in this chapter).

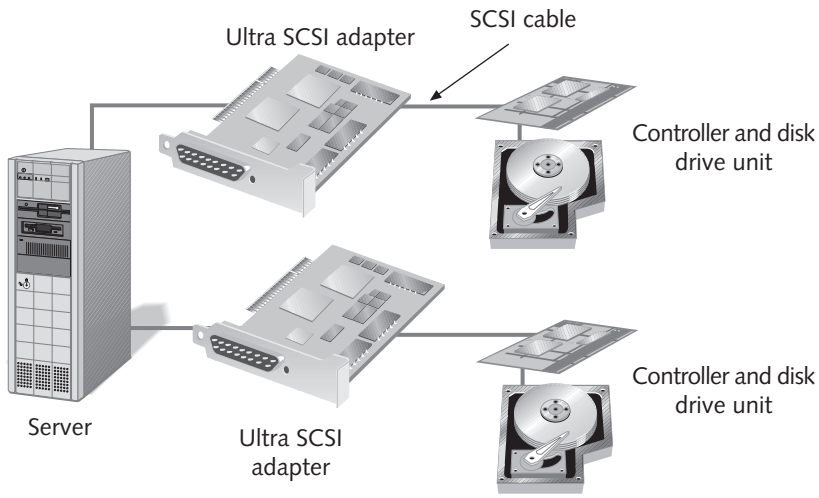

Figure 2-7 Using two SCSI adapters to create separate data paths for hard disk drives

One method to significantly increase performance on a server is to purchase two or more hard disk drives and divide the flow of data between two or more data pathways by placing the drives on different adapters.

Using Fibre Channel

A newer alternative to SCSI is **Fibre Channel**, a high-speed communications method used to connect disk storage devices to computers. You can purchase a Fibre Channel Host Bus Adapter (HBA) to install in a PCI, EISA, MCA, or SBUS (Sun Microsystems SPARC bus) expansion slot in a server and attach Fibre-Channel-compatible disk drives (including RAID) to the HBA. This adaptation is compatible with both the SCSI, and IP protocols (see Chapter 3). Two important advantages of Fibre Channel in a server are that it is fast (from 100 Mbps to 1 Gbps) and that it enables peripherals to be attached further away (up to 10 kilometers) than other peripheral connection methods. Windows 2000 Server currently supports Fibre Channel using SCSI-based protocol communications. Server hardware applications of Fibre Channel use the Fibre Channel Arbitrated Loop (FC-AL) standard. This standard enables connection of up to 126 devices (host computers and peripherals), up to 1 Gbps data transfer, and hot-pluggable adapters and devices. ("Hot-pluggable" means that you can plug an adapter into a server or attach a new disk drive without shutting down the server.) Unlike SCSI, FC-AL requires no terminators, which makes adding a new device easier.

Disk Storage Fault Tolerance

Because hard disk drives are prone to failure, one of the best data security measures is to plan for disk redundancy in servers and host computers. This is accomplished in two ways: by installing backup disks and by installing RAID drives.

One fault-tolerance option common to many server and host computer operating systems is **disk mirroring** to store redundant data. With disk mirroring, there are two separate drives for each disk volume of data. One is the main drive used to handle all of the user's requests to access or write data. The second drive contains a mirror image of the data on the first. Each time there is an update or deletion, it is made on the main drive and replicated on the second. If the main drive fails, the mirror drive takes over with no data loss. In disk mirroring, both drives are attached to the same disk controller or SCSI adapter. For example, one SCSI adapter plugged into a slot on the computer's main board might have two disk drives, the primary drive and a mirrored drive (Figure 2-8).

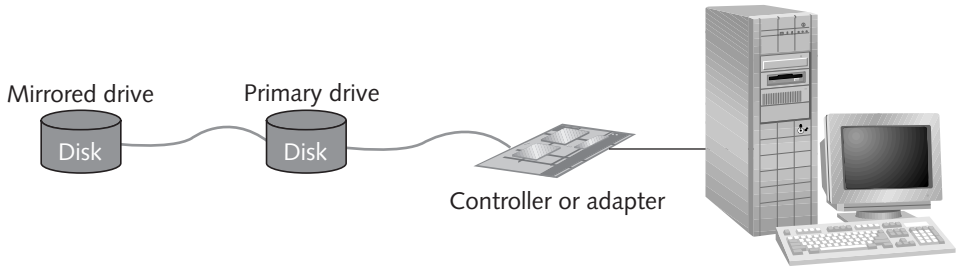

Figure 2-8 Disk mirroring

Disk mirroring has a weakness: it leaves the data inaccessible if the controller or adapter fails. To compensate for that weakness, you can use **disk duplexing**, another fault-tolerance method, combining disk mirroring with redundant adapters or controllers. Each disk is still mirrored by using a second backup disk, but the backup disk is placed on a controller or adapter that is separate from the one used by the main disk (Figure 2-9). If the primary disk, controller, or adapter fails, users may continue their work on the redundant one. Some operating systems can switch from the primary to the backup disk without interruption in service to the users, while others require that the server or host computer be rebooted to use the mirror drive instead of the failed main drive.

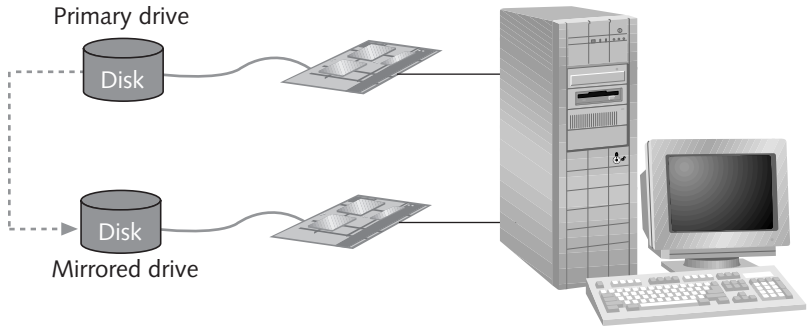

Figure 2-9 Disk duplexing

Another approach to disk redundancy is the use of a **redundant array of inexpensive** (or **independent**) **disks** (**RAID**). RAID is a set of standards for lengthening disk life and preventing data loss. There are eight levels of RAID, beginning with the use of disk striping. **Striping** is the ability to spread data over multiple disk volumes. For example, part of a large file may be written to one volume and part to another. The goal is to spread disk activity equally across all volumes, preventing wear from being focused on a single volume in a set. The six essential RAID levels are as follows:

- *RAID level 0*: Striping with no other redundancy features is RAID level 0. Striping is used to extend disk life and to improve performance. Data access on striped volumes is fast because of the way the data is divided into blocks that are quickly accessed through multiple disk reads and data paths. A significant disadvantage to using level 0 striping is that if one disk fails, you can expect a large data loss on all volumes. RAID level 0 is supported in Windows 2000, using 2 to 32 disks in a set. In Windows 2000 Server, this is called striped volumes, whereas in Windows NT 4.0 it is called stripe sets.
- *RAID level 1*: This level employs simple disk mirroring and is used on smaller networks, in situations in which fast read access is more important than fast disk writing, and as a means to duplicate the operating system files in the event of a disk failure. Windows 2000 Server supports level 1, but includes disk duplexing as well as mirroring through the fault-tolerance driver Ftdisk.sys. If there are three or more volumes to be mirrored or duplexed, this solution is more expensive than the other RAID levels. When you plan for disk mirroring, remember that write access is slower than read access, because information must be written twice, once on the primary disk and once on the secondary disk. Many server administrators consider disk mirroring and disk duplexing to offer the best guarantee of data recovery when there is a disk failure.
- *RAID level 2*: This uses an array of disks whereby the data is striped across all disks in the array. Also, in this method all disks store error-correction information that enables the array to reconstruct data from a failed disk. The advantages of level 2 are that disk wear is reduced and data can be reconstructed if a disk fails.

- *RAID level 3*: Like level 2, RAID level 3 uses disk striping and stores error-correcting information, but the information is only written to one disk in the array. If that disk fails, the array cannot rebuild its contents.
- *RAID level 4*: This level stripes data and stores error-correcting information on all drives, in a manner similar to level 2. An added feature is its ability to perform checksum verification. The checksum is a sum of bits in a file. When a file is recreated after a disk failure, the checksum previously stored for that file is checked against the actual file after it is reconstructed. If the two do not match, you will know that the file may be corrupted. RAID levels 2 through 4 are not supported by Windows 2000 Server because they do not offer the full protection found in level 5.
- *RAID level 5*: Level 5 combines the best features of RAID, including striping, error correction, and checksum verification. Windows 2000 Server supports level 5, calling it "stripe set with parity on basic disks" or a RAID-5 volume, depending on the disk architecture. Whereas level 4 stores checksum data on only one disk, level 5 spreads both error-correction and checksum data over all of the disks, so there is no single point of failure. This level uses more memory than other RAID levels, with at least 16 MB recommended as additional memory for system functions. In addition, level 5 requires at least three disks in the RAID array. Recovery from a failed disk provides roughly the same guarantee as with disk mirroring, but takes longer with level 5. However, if more than one disk fails in the array, you may not be able to recover some or all of the data in the entire array of disks, in which case you will have to restore data from a tape backup.

Windows 2000 Server supports only RAID levels 0, 1, and 5 for disk fault tolerance, with levels 1 and 5 recommended. RAID level 0 is not recommended in most situations because it does not really provide fault tolerance, except to help extend the life of disks. All three RAID levels support FAT- and NTFS- formatted disks. RAID fault-tolerance methods are not supported in Windows 2000 Professional. When you decide upon using RAID level 1 or RAID level 5, consider the following:

- The boot and system files can be placed on RAID level 1, but not on RAID level 5. Thus, if you use RAID level 5, these files must be on a separate disk or a separate RAID level 1 disk set (except for hardware RAID, which is discussed in the next section).
- RAID level 1 uses two hard disks, and RAID level 5 uses from 3 to 32.
- RAID level 1 is more expensive to implement than RAID level 5, when you consider the cost on the basis of each megabyte of storage. Keep in mind that in RAID level 1, half of your total disk space is used for redundancy, whereas that value is one-third or less for RAID level 5. The amount of RAID level 5 used for parity is $1/n$ where n is the number of disk drives in the array.
- RAID level 5 requires more memory than RAID level 1.
- Disk read access is faster in RAID level 1 and RAID level 5 than is write access, with read access for RAID level 1 identical to that of a disk that does not have RAID.

- Because RAID level 5 involves more disks (and more spindles) and because the read/write heads can acquire data simultaneously across striped volumes, it has much faster read access than RAID level 1.

On a Windows 2000 server, mirrored/duplexed and RAID disks are set up using the Disk Management snap-in in the Microsoft Management Console (MMC), a central tool for managing the server disk and CD-ROM drives. The Disk Management snap-in (Figure 2-10) replaces the Disk Manager used in Windows NT 4.0, but offers similar disk management options, as follows:

- Viewing status information about drives, including file system information
- Creating an NTFS partition on a new disk drive
- Combining two physical drives into one logical drive
- Changing drive letter assignments
- Partitioning and formatting drives
- Extending a partitioned drive or a volume to include any free space not already allocated
- Creating a mirrored volume
- Creating a striped or RAID-5 volume
- Creating a spanned or extended volume

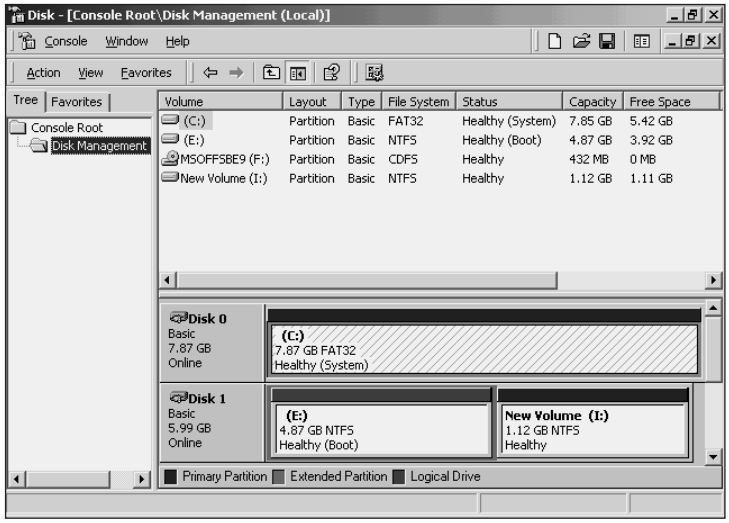

Figure 2-10 Windows 2000 Disk Management snap-in

Selecting Disk Storage Fault Tolerance

The disk storage fault tolerance-method you use depends on factors such as:

- The importance of the data stored on the server
- How soon a server must be working after a disk problem
- The amount of data stored on the server
- How fast the data must be accessed
- Budget constraints

Consider three different situations for planning fault tolerance. In the first, you are planning a server to be used by a team of 10 software developers for a full-featured human resources hiring system used by large department stores. None of the software on this server is used in a live environment, because the server is strictly for testing and development. Also, the developers only work with limited test data instead of a large human resources database. However, the application developers are under rigid deadlines for completing each phase of the software. In this situation, the disk storage requirements are not large and a disk crash is unlikely to cause them to lose data that cannot be replaced. The main concern is to have the server quickly working again after a disk failure, so the developers can keep up with their deadlines. In this situation, disk mirroring or RAID level 1 is likely to meet their needs. If the main disk drive is lost, the mirrored disk can quickly take over so they do not lose precious time. Disk duplexing is another alternative, if there is a concern that they may lose an adapter or disk controller and sacrifice time due to this type of failure.

In another example, a Windows 2000 server is used by tellers and loan officers in a small bank with 15 employees. The bank cannot afford to risk loss of data or downtime because of a failed disk drive or controller. Also, during certain peak periods, they experience heavy disk read and write activity. The bank is likely to benefit from dividing data among two disk drives on different SCSI adapters, with a mirrored drive for each main drive. The disk load is spread between two drives for faster access during peak times at the bank. If one disk drive fails, the mirrored drive can take over. If an adapter fails, both of the drives on that adapter can be switched to the remaining adapter until the failed adapter is replaced. An even better option is to connect two small RAID level 5 arrays to two different adapters. This provides two paths for better disk response and the advantage of disk redundancy should one of the RAID drives fail. Also, if an adapter fails, its RAID drive can be switched temporarily to the working adapter.

A third scenario is a mail-order company that sells collectibles, stamps, and plates. This company has 55 customer service representatives, who take telephone orders and enter the data in an interactive order- entry database on a Windows 2000 server. Customer service representatives work around the clock, and any server downtime costs hundreds of dollars a minute. Also, the company cannot afford to lose any data due to a failed drive, because it could mean a loss of thousands of dollars. This is a good application for multiple data paths and large RAID level 5 arrays. The multiple data paths will help the server respond to aggressive disk demands, and the RAID level 5 arrays prevent data loss if a drive in an array fails.

Also, this setup prevents downtime, because the disk array continues working even though a drive has crashed.

Software RAID Compared to Hardware RAID

Two approaches to RAID can be implemented on a server: software RAID and hardware RAID. Software RAID implements fault tolerance through the server's operating system, such as using RAID levels 1 or 5 through the Windows 2000 Disk Management snap-in. Hardware RAID is implemented through the server hardware and is independent of the operating system. Many manufacturers implement hardware RAID on the adapter, such as a SCSI adapter, to which the disk drives are connected. The RAID logic is contained in a chip on the adapter. Also, there often is a battery connected to the chip that ensures that the chip never loses power and has fault tolerance to retain the RAID setup even when there is a power outage. Hardware RAID is more expensive than software RAID, but offers many advantages over software RAID:

- Faster read and write response
- The ability to place boot and system files on different RAID levels, such as RAID levels 1 and 5
- The ability to "hot-swap" a failed disk with one that works or is new, thus replacing the disk without shutting down the server (this option can vary by manufacturer)
- More setup options to retrieve damaged data and to combine different RAID levels within one array of disks, such as mirroring two disks using RAID level 1 and setting up five disks for RAID level 5 in a seven-disk array (the RAID options depend on what the manufacturer offers)

One limitation of hardware RAID is that with some vendors you might be required to purchase all components from the same vendor—adapter, cable, and disk drives, for example. When you purchase hardware RAID, find out first if you have the option to use disk drives from other vendors and if the drives can be upgraded to larger sizes. For instance, if you purchase five 9 MB drives to start, can you replace them with larger drives (20 MB for example), as your needs grow?

When you purchase RAID, look for options that give you better management capabilities. One important option is the ability to set up and manage RAID from within Windows 2000 Server, instead of having to access setup from a control key combination before the operating system is loaded when you boot. Another option is to have lights or an LED display on the front of the server to tell you the status of the RAID, such as when a disk has failed.

Backup Media

Another form of redundancy to protect data is equipping a server with backup capabilities. Windows 2000 Server supports backup to different kinds of removable media that include tape, Zip/Jaz disks, and CD-ROMs. Tape backup is used for large backup needs, because a single tape can hold over 40 GB. Byte for byte, tape backup is usually the least expensive and most convenient way to back up an entire server. When you have smaller backup needs, such as backing up a specific set of files, then Zip/Jaz disks or rewriteable CD-ROMs are likely to be more convenient and faster than tape. For example, a 100 MB or 1 GB Zip/Jaz disk may be all that is necessary to back up key accounting files each evening and when your organization performs the monthly accounting system maintenance. The Zip/Jaz disk is convenient and will be faster than using tape in this situation.

When you outfit a system with tape, Zip, and/or CD-ROM drives, consider using SCSI technology for each and do not connect a drive used for backups to a SCSI adapter used for hard disk drives. For example, a tape drive used to back up Windows 2000 servers on a network can be mounted inside a server or it can be an external unit; either way it should be attached as the only device on an adapter (Figure 2-11).

If hard disks also are on the same adapter as the tape drive, for example, server access to the disks may be slowed due to the high traffic through that adapter during backups.

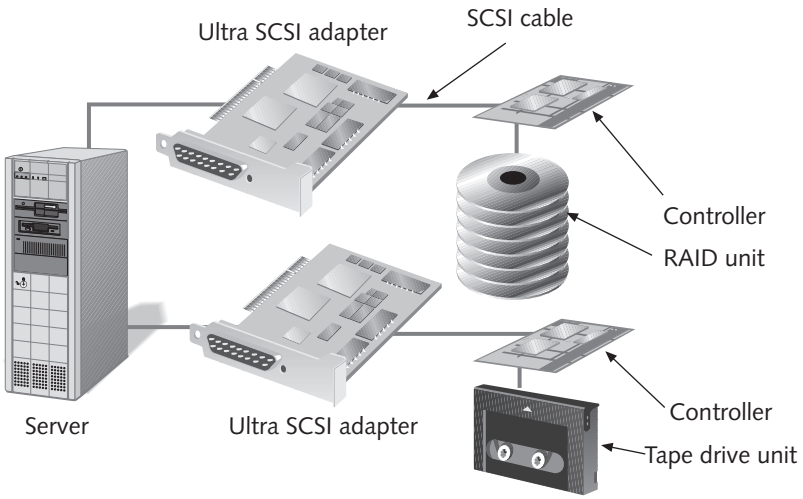

Figure 2-11 Connecting a tape drive to a separate adapter

Reliable backup systems and media are one of the best investments you can make. When data is lost, the expense of backup equipment and media is small compared to the cost of the human resources needed to reconstruct data

Choosing a CD-ROM Drive

A CD-ROM drive is necessary to load the Windows 2000 Server operating system, unless you choose to load the system over the network. Another good reason for having the drive is to run software that is only available on CD-ROM. In the law office example used earlier, the CD-ROM drive might be used to make legal forms software available to all attorneys and paralegals connected to the server. On school lab servers, CD-ROM drives can be used to make study resources available, such as dictionaries, encyclopedias, and writing aids.

Another way to implement CD-ROM access is to purchase a CD-ROM "jukebox" or server that can be connected to the Windows 2000 server by using a SCSI adapter or Fibre Channel (Figure 2-12). CD-Technology, DEC/Compaq, NEC, Plextor, Sony, and Toshiba are examples of CD-ROM vendors on Microsoft's HCL. CD-ROMs come in various speeds ranging up to 48X and faster. Windows 2000 requires that you have a 12X or faster CD-ROM drive. If you plan to use multiple CD-ROMs for sharing through a server, investigate the many options for CD-ROM arrays. The arrays offer throughput that can match Ultra SCSI speeds. CD-ROM arrays come in various configurations, such as 7, 10, 14, and 32 CD-ROM drives in a single tower array. One user can be connected to one or more CD-ROMs in the array through a Windows 2000 server.

Figure 2-12 CD-ROM "jukebox"

Windows NT 4.0 does not support Digital Video Discs (DVD), but Windows 2000 does. It is not necessary to have a DVD drive on a server, unless you plan to use it for network access to movies, for example.

Setting Up and Testing the Server

There are several steps you can take once your new server arrives, which will help you be ready for Windows 2000 Server installation. A first step is to boot the computer to make sure it works. As the server boots, it is likely to go through a test of the banks of RAM.

If you need to install the NIC, turn off the computer, unplug it from the wall outlet, and remove the monitor, mouse, and keyboard. Next, remove the cover, according to the manufacturer's instructions. Locate an empty slot for the NIC. The circuit board slots are usually located at the rear of the main circuit board or on a separate board that connects to the main board. At the end of each slot, there is a slot cover on the frame of the server. Remove the slot cover before installing the NIC. Consult the manual to be certain which are 32-bit EISA and PCI slots. Make sure you plug the NIC into the appropriate type of slot, depending on the type of NIC (EISA or PCI).

After removing the slot cover, check to make sure your wrist grounding strap is on securely. Remove the NIC from its antistatic protective bag and firmly install it into a slot. You may hear a slight click as the card goes into place against the bottom of the slot.

Plan to execute a fast test of the NIC to be certain that the NIC is installed properly. Reattach the monitor, mouse, keyboard, and power cord. Once the computer is on, run the test software included with the NIC. The test program should indicate the NIC is installed correctly and is ready to be used.

Repeat the same type of procedures if you also need to install one or more SCSI adapters. Install SCSI adapters in the appropriate EISA or PCI expansion slots. If possible, leave space between boards inside the server (empty slots between occupied slots). This allows for better air circulation and reduces the impact of heat generated by the computer. It also helps to prolong the life of the boards.

After the SCSI adapters are installed, boot the computer again to make sure it boots properly. If the adapter manufacturer has included test software, make sure you use it to test the installation. Once you are certain that the newly installed components are working, let the computer run for several days as a "burn-in" period. Any defective components are likely to fail after you run the computer for several days. If there is a defective component, such as a monitor or floppy disk drive, you will have the opportunity to replace it before starting the Windows 2000 Server installation. This is much easier than puzzling over Windows 2000 Server installation problems caused by defective hardware.

Chapter Summary

- The hardware used for servers are not just PCs anymore. There is a wide range of sophisticated options from fast processors to fault-tolerant disk drives. The challenge for you is putting together server specifications that match your organization's needs.
- When you plan the hardware, begin with specifications that match the role the server will play on the network. It is better to start with too much server than with too little. A server that begins its job undersized will quickly be a source of problems. At first an undersized server may appear to be a network problem because of slow response and delays at the server. You may spend hours locating the problem, and your users quickly will lose confidence in the installation. Well-planned server hardware enables you to get a fast start, so you can proceed with the next steps in managing the server. Also, the server will quickly spawn confidence, enabling users to immediately enjoy productivity gains.

- The first step in selecting hardware is to check the Microsoft hardware compatibility list (HCL) to make sure that all components will work with Windows 2000 Server. One reason for taking this step is to ensure that drivers are available for each hardware component and that they are compatible with the operating system installation. The CPU you select from the list depends on the anticipated server load. In many cases a Pentium-based CPU is a good selection for small and medium-sized installations (a few users to several hundred). If the installation is for a demanding client/server system, a multimedia server, or a large Web server, a Xeon, SMP, or RISC-based computer is likely to be needed.
- Computers use different types of bus architectures, such as ISA, EISA, MCA, and PCI. For most installations a PCI-based computer works best, with perhaps one or two EISA expansion slots. The EISA slots are compatible with older adapters, while the predominant PCI slots provide high throughput for critical components, such as the NIC. The selection of the NIC depends on network and computer requirements. If the network is 100 Mbps using twisted-pair cable, the NIC will need to match those requirements. Also, modern servers should be equipped with one or more USB ports and Plug and Play compatibility. I_2O architecture is an added feature that can significantly improve a server's performance.
- The selection of disk storage depends on the requirements for factors such as capacity, speed, and data transfer rate. SCSI adapters are generally used to connect hard disks to the computer because of their fast throughput. Fibre Channel is an even faster and more flexible option for servers that experience heavy disk access by a large number of users. Fault-tolerance options also need to be considered when disk storage is selected. Disk mirroring, disk duplexing, and RAID are fault- tolerance methods supported by Windows 2000 Server. Installing removable backup systems is another way to implement fault tolerance so that data on hard disks can be backed up regularly.
- Most servers have at least one CD-ROM drive. Options are available to connect an array of CD-ROM drives for situations in which the server makes multiple CD-ROMs available to users. Windows 2000 is compatible with regular CD-ROM and DVD drives, with at least a 12X drive recommended.
- The last stage in preparing the server hardware is to install components such as NICs, SCSI adapters, RAM, and tape drives (if they are not preinstalled by the manufacturer). Each device should be tested after it is installed. The server and components should have a burn-in period of several days to make sure that all parts are functional before the Windows 2000 Server operating system is loaded.

In the next chapter, you learn about Windows 2000 protocol options to meet nearly every networking possibility, including Internet communications and communications with other server operating systems, such as NetWare. You also continue to learn about the planning process involved in making preparations to implement Windows 2000 Server in different kinds of situations.

KEY TERMS

bus — A pathway in a computer used to transmit information. This pathway is used to send CPU instructions and other data being transferred within the computer.

bus mastering — A process that reduces the reliance on the CPU for input/output activities on a computer's bus. Interface cards that have bus mastering can take control of the bus for faster data flow.

clock speed — Rate at which the CPU sends bursts of data through a computer's buses.

data transfer rate — Speed at which data moves through the disk controller along the data channel to a disk drive.

disk access time — Amount of time it takes for a disk drive to read or write data by moving a read/write head to the location of the data.

disk duplexing — A fault-tolerance method similar to disk mirroring in that it prevents data loss by duplicating data from a main disk to a backup disk; but disk duplexing places the backup disk on a different controller or adapter than is used by the main disk.

disk mirroring — A fault-tolerance method that prevents data loss by duplicating data from a main disk to a backup disk. Some operating systems also refer to this as disk shadowing.

driver — Software that enables a computer to communicate with devices like network interface cards, printers, monitors, and hard disk drives. Each driver has a specific purpose, such as to handle network communications.

Enhanced Small Device Interface (**ESDI**) — An early device interface for computer peripherals and hard disk drives.

error checking and correcting memory (**ECC**) — Memory that can correct some types of memory problems without causing computer operations to halt.

Extended Industry Standard Architecture (**EISA**) — A computer bus design that incorporates 32-bit communications within a computer. It is an industry standard used by several computer manufacturers.

Fibre Channel — A high-speed method for connecting computer peripherals, such as disk drives, to servers and other host computers through copper and fiber-optic cable. Current implementations of Fibre Channel in Windows 2000 servers provide data transfer rates of up to 1 Gbps.

firmware — Software that is stored on a chip in a device, such as in a ROM chip, and that is used to control basic functions of the device such as communication with a disk drive.

full duplex — The capacity to send and receive signals at the same time.

half duplex — The ability to send or receive signals, but not simultaneously.

hardware compatibility list (**HCL**) — A list of computer hardware tested by Microsoft and determined to be compatible with Windows 2000 Server.

Industry Standard Architecture (**ISA**) — An older expansion bus design dating back to the 1980s, supporting 8-bit and 16-bit cards and with a data transfer rate of 8 MB per second.

Integrated Device Electronics (**IDE**) — An inexpensive hard disk interface that is used on Intel-based computers from the 80286 to Pentium computers.

intelligent input/output (**I_2O**) — A computer communications architecture that removes some of the I/O processing activities from the main processor to I_2O processors on peripherals designed for I_2O architectures, such as hard disks. I_2O devices use one general device driver for all I_2O-compliant devices.

Micro Channel Architecture (**MCA**) — A bus architecture that is used in older IBM Intel-based computers. It provides 32-bit communications within the computer.

network interface card (**NIC**) — An adapter board designed to connect a workstation, server, or other network equipment to a network medium.

Peripheral Computer Interface (**PCI**) — A computer bus design that supports 32-bit and 64-bit bus communication for high-speed operations.

Plug and Play (**PnP**) — Ability of added computer hardware, such as an adapter or modem, to identify itself to the computer operating system for installation.

processor cache — A special data storage area used only by the system processor and located on either the processor chip or a chip separate from the processor.

Reduced Instruction Set Computer (**RISC**) — A computer that has a CPU that requires fewer instructions for common operations. The processor works faster because the commands to the CPU are reduced.

redundant array of inexpensive (or **independent**) **disks** (**RAID**) — A set of standards designed to extend the life of hard disk drives and to prevent data loss from a hard disk failure.

shared disk model — Linking two or more servers to operate as one and to equally share resources that include disk, CD-ROM, and tape storage.

shared nothing model — Linking two or more servers to operate as one, but with each owning particular disk, CD-ROM, and tape resources.

Small Computer System Interface (**SCSI**) — A 32- or 64-bit computer adapter that transports data between one or more attached devices, such as hard disks, and the computer. There are several types of SCSI adapters, including SCSI, SCSI-2, SCSI-3, wide SCSI, narrow SCSI, wide Ultra SCSI, and Ultra2 SCSI. All are used to provide high-speed data transfer to reduce bottlenecks within the computer.

striping — A data storage method that breaks up data files across all volumes of a disk set to minimize wear on a single volume.

symmetric multiprocessor (**SMP**) — A type of computer with two or more CPUs that share the processing load.

universal serial bus (**USB**) — A bus standard that enables you to attach all types of devices—keyboards, cameras, pointing devices, telephones, and tape drives, for example —to one bus port on a computer. Up to 127 devices can be attached to one port, and it is not necessary to power off the computer when you attach a device. USB was developed to replace the traditional serial and parallel bus technologies on computers.

Review Questions

1. You are planning a server for a company that wants to implement hard disk fault tolerance. The company is not worried about expense, but does want a server that has very good read and write performance. Which of the following would you implement?
   a. software RAID level 1
   b. hardware RAID level 5
   c. IDE controllers
   d. a bus extender
2. Which type of NIC is likely to provide the fastest performance?
   a. PCI
   b. MCA
   c. ISA
   d. EISA
3. Your assistant is installing a NIC in a Windows 2000 Server that is connected to a full-duplex switch port. How should the NIC be set up?
   a. for 10 Mbps communication
   b. for ATM communication
   c. for half-duplex communication
   d. for full-duplex communication
4. Which of the following are features of a USB port on a computer running Windows 2000 Server?
   a. Plug and Play
   b. ability to connect a device without shutting down the computer
   c. connectivity for up to 180 devices
   d. all of the above
   e. only a and b
   f. only b and c
5. Which type of SCSI interface is fastest?
   a. narrow SCSI-2
   b. wide Ultra SCSI
   c. Ultra2 SCSI
   d. wide SCSI-2

6. You have installed a SCSI adapter and connected three hard drives to it. When you start the computer, it does not recognize any of the hard drives. Which of the following might you do to troubleshoot?
   a. Check the addresses for the drives.
   b. Check the battery on the SCSI adapter.
   c. Check the terminator on the last drive.
   d. all of the above
   e. only a and b
   f. only a and c
7. Which type of adapter reduces reliance on the CPU for I/O processing?
   a. L2
   b. bus mastering
   c. parity leveling
   d. dual channel
8. You are looking at disk drive and adapter specifications because you want to ensure fast access to data. Which of the following is most important, when you consider the types of equipment on the market today?
   a. head rotation
   b. disk access time
   c. data transfer rate
   d. disk braking method
9. You have a small Windows 2000 Server implementation in which you need 2.2 GB of space for data, and there are two 5 GB disk drives already installed. Which of the following would be your best bet in terms of providing protection for your data and the operating system files?
   a. RAID level 0
   b. disk mirroring
   c. RAID level 5
   d. Just install the disks on a SCSI adapter.
10. You need to perform a nightly backup of a server that holds 72 GB of data. Which removable medium is your best choice??
    a. Zip disk
    b. CD-ROM
    c. tape
    d. high-density floppy disk

11. Which of the following is compatible with 32-bit and 64-bit bus architecture?
    a. EISA
    b. MCA
    c. PCI
    d. all of the above
    e. none of the above
12. You are setting up two clustered servers so that each has equal access to disk storage. Which model is this?
    a. shared disk
    b. shared CPU
    c. shared nothing
    d. shared master
13. What is the minimum amount of hard disk space necessary to install Windows 2000 Server on an Intel-based computer?
    a. 685 MB
    b. 742 MB
    c. 522 MB
    d. 367 MB
14. You are working on specifications for memory for your server. Your boss, who is very conscious of the budget, says you only need memory for the operating system. Is he right? As you consider the options, keep in mind that there will be 45 users of the server, which will be set up for TCP/IP and DNS Services.
    a. Yes, you only really need memory for the operating system.
    b. No, you need memory for the operating system and to run TCP/IP.
    c. No, you need memory for operating system, users who access the server, and services such as DNS.
    d. No, because all servers should be outfitted with at least 512 MB regardless of the operating system needs.
15. Which of the following are characteristics of Fibre Channel?
    a. Up to 126 devices can be connected.
    b. It does not use a terminator at the end.
    c. Its maximum reach is limited to 9 feet.
    d. all of the above
    e. only a and b
    f. only a and c

16. Which of the following gives you protection against a hard drive adapter failure?
    a. mirroring
    b. sectoring
    c. channel diversion
    d. duplexing
17. Your server seems to be experiencing memory errors that will not self-correct. One problem is that it might not have what type of memory?
    a. 70 nanosecond
    b. RAM_2
    c. ECC
    d. 72-pin
18. One difference between Windows 2000 Server and Windows 2000 Professional is that:
    a. Windows 2000 Professional does not support disk fault tolerance.
    b. Windows 2000 Server has fewer NIC drivers that can be adapted for it because it supports more connections.
    c. Windows 2000 Professional runs software faster.
    d. Windows 2000 Server requires less memory.
19. Which processor does not use Level 2 caching?
    a. Pentium II
    b. Pentium Pro
    c. Pentium III
    d. Celeron
20. You are working with your boss to develop specifications for a server, and she asks how much disk space is actually available for data in RAID level 5 when there are four disks. Which of the following the appropriate answer?
    a. 90%
    b. 75%
    c. 65%
    d. 50%
21. Your community college is working to replace a Pentium 233 MHz Web server because it is extremely slow and its use is growing geometrically. Which of the following would give you the best performance in terms of processor caching?
    a. Pentium Pro
    b. Pentium II
    c. Pentium III
    d. Pentium III Xeon

22. You have set up RAID 5 via SCSI connectivity on your server. In the middle of the afternoon, the server diagnostic lights show that two drives have failed. What is your most likely recourse?
    a. You have no problems because up to two drives can fail without loss of data.
    b. Replace the terminators on both disk controllers.
    c. Perform a restore from your most recent tape backup.
    d. Use the Windows 2000 Server Disk Management snap-in to reinitialize each drive.
23. What is the minimum CD-ROM drive that can be used with Windows 2000 Server?
    a. 48X
    b. 32X
    c. 24X
    d. 12X
24. Your boss has found a bargain in a Pentium II computer for a server. What step(s) is (are) most important in making certain that you can install Windows 2000 Server on it?
    a. Check to make sure it matches the minimum hardware requirements.
    b. Check to see if it is listed in the HCL.
    c. Make sure that it has a USB port.
    d. all of the above
    e. only a and b
    f. only a and c
25. Which of the following differentiates hardware RAID from software RAID?
    a. Hardware RAID is usually more expensive.
    b. You cannot put boot and system files on hardware RAID.
    c. You can only implement RAID level 1 on software RAID.
    d. all of the above
    e. only a and b
    f. only a and c

HANDS-ON PROJECTS

Project 2-1

In this hands-on activity, you view the HCL for Windows 2000 Server. You will need the Windows 2000 Server CD-ROM.

To access the HCL:

1. Log on to Windows 2000 Server (or Professional).
2. Insert the Windows 2000 Server CD-ROM.

3. Double-click **My Computer** on the desktop.
4. Double-click the drive that contains the CD-ROM, such as drive D.
5. Click **Browse This CD**, if the Microsoft Windows 2000 CD dialog box is displayed.
6. Double-click the **Support** folder.
7. Double-click the **Hcl.txt** file (or **HCL**, depending on your settings for viewing files) in the Support folder and scroll through its contents. Maximize the Notepad window, if necessary.
8. Find four manufacturers of display monitors on the list and record them in your lab journal or in a word-processed document.
9. Find four manufacturers of pointing devices and two manufacturers of USB controllers. Record this information in your lab journal or word-processed document.
10. Close Notepad when you are finished.
11. Close the Support, Microsoft Windows 2000 CD-ROM, and My Computer windows.

Project 2-2

In this project, you view the hardware components set up in your computer.

To view the components:

1. Log on to Windows 2000.
2. Click **Start**, point to **Settings**, and then click **Control Panel**.
3. Double-click the **Add/Remove Hardware** icon.
4. When the Add/Remove Hardware Wizard starts, click **Next**.
5. Select **Add/Troubleshoot a device** and then click **Next**.
6. Wait a few moments as the Wizard searches for new devices.
7. Scroll through the devices text box.
8. Is there a PCI bus in the computer? What other buses are there?
9. What type of processor is installed? If there is a tape drive, what kind is it?
10. Record your observations in your lab journal or in a word-processed document.
11. Click **Cancel** to exit the Wizard and then close the Control Panel.

Project 2-3

In this hands-on activity you check the BIOS setup screen on a computer to determine if it has an option to enable Plug and Play.

To check the Plug and Play option in the BIOS setup:

1. Find out how to access the computer's BIOS from your instructor or lab assistant. On most computers you access the BIOS setup screen by typing a specific key right after turning on the computer's power. For example, some computers use the F1 or Del keys.
2. Follow the on-screen instructions to view or access the BIOS setup menu(s).

3. If there are two or more menus, such as Main, Advanced, Security, and so on, use the right and left arrow keys (or the keys mentioned on-screen) to view the different menus and their options.
4. Look for a reference to Plug and Play, such as one that says Plug and Play O/S [Yes]. In this example, Yes means it is enabled, and No means it is not.
5. Make sure that you exit the BIOS setup without making any changes. On some computers, you can exit by pressing Esc and typing no to the query about saving your changes.
6. Record your findings in your lab journal or in a word-processed document.

Project 2-4

In this project, you find the location of the NIC driver in a computer running Windows 2000 Server. Log onto an account with Administrator privileges for this project.

To find the driver location:

1. Log on to Windows 2000.
2. Click **Start**, point to **Settings**, and then click **Control Panel**.
3. Double-click the **System** icon.
4. Click the **Hardware** tab and the **Device Manager** button.
5. Double-click **Network Adapters** and then double-click the actual network adapter that appears under Network Adapters.
6. Click the **Driver** tab.
7. Click the **Driver Details** button.
8. In the Driver files text box, notice the location of the driver and its filename. Record both.
9. Click **OK** and then click **Cancel**.
10. Close the Device Manager and then click **Cancel**.
11. Close the Control Panel.

Project 2-5

In this project, you view the properties and capabilities of a NIC in a server. You will need access to a computer running Windows 2000 Server (or Windows 2000 Professional) and to an account with Administrator privileges.

To view the NIC properties and capabilities:

1. Log on to Windows 2000 Server.
2. Click **Start**, point to **Settings**, and then click **Network and Dial-Up Connections**.
3. Right-click **Local Area Connection** and then click **Properties**.
4. Make sure the General tab is displayed and then click the **Configure** button for the NIC.

5. Click the **Advanced** tab and notice the properties available through the NIC, such as Duplex Mode and Media Type. Record the available properties in your lab journal or in a word-processed document.
6. Click the **Duplex Mode** property and determine the current duplex setting in the Value: box. Click the list arrow in the Value: box to determine which other duplex settings are available.
7. Click the **Media Type** property and determine the media options in the Value: box.
8. Select other properties and view their associated options.
9. Click the other tabs available for the NIC, which can include Driver, Resources, and Power Management (depending on the NIC's capabilities and driver).
10. Record your observations in your lab journal or in a word-processed document before exiting.
11. Click **Cancel** on the NIC properties dialog box and **Cancel** on the Local Area Connection Properties dialog box.
12. Close the Network and Dial-up Connections dialog box, if it is displayed.

In this and in other projects that involve NICs, the NIC properties and tabs that you view in the NIC properties dialog box may vary slightly depending on the type of NIC installed, because these are influenced by the manufacturer and the NIC driver written by the manufacturer.

Project 2-6

In this hands-on assignment, you practice obtaining a NIC driver from a vendor's Web site. You need access to Microsoft Internet Explorer on a workstation or server and Internet access.

To find a NIC driver:

1. Open Internet Explorer, for example by doubling-clicking it on the desktop of Windows 95, Windows 98, Windows NT, or Windows 2000.
2. Enter **www.3com.com** in the address line.
3. Find the link for support and click it.
4. Click the link for network interface cards.
5. Select a technology, such as Ethernet, or a card type, such as Etherlink III, or a product number, such as 3C590. Click **Go There** or the hyperlink to search for your selection.
6. Choose a card, such as the EtherLink III PCI and then click its hyperlink. If you selected the product number in Step 5, skip this step and go to Step 7.
7. Find the Windows 2000 driver or lastest Windows NDIS driver on the list of drivers.
8. What other drivers are available?
9. How would you download a driver?

10. Record your answers to Steps 8–9 and any other observations on this project in your lab journal or in a word-processed document.
11. Close Internet Explorer.

The Web site page options may change over time. If the Web page has changed since this writing, use the Support option and search to find drivers or network interface cards.

Project 2-7

In this hands-on activity, you use Task Manager to determine the amount of memory used while running the IIS service in Windows 2000 Server. IIS must already be installed on the server before you start.

To determine the amount of memory used by IIS:

1. Log on to Windows 2000 Server.
2. Type **Ctl+Alt+Del**.
3. Click the **Task Manager** button on the Windows Security dialog box
4. Click the **Processes** tab, if it is not already displayed.
5. Use the scroll bar to find the IIssrv.exe service,. Next, find Mstask.exe. For each service find the amount of memory that it uses under the Mem Usage column.
6. Record the memory usage in your lab journal or in a word-processed document.
7. Close Windows Task Manager.

CASE PROJECT

Aspen Consulting Project: Planning Server Specifications

Moose Jaw Outfitters is a "mail-order" company that sells outdoor clothing in Canada and the U.S. Although they are known as a mail-order company, Moose Jaw Outfitters does most of its business via telephone and an Internet Web site. Actual orders sent through the mail represent their third largest source of sales. The company also has two large outlet stores, one in Winnipeg, Canada and another in St. Cloud, Minnesota, which represent the fourth largest source of income.

The Winnipeg store is the location of the main headquarters for Moose Jaw Outfitters, where the company maintains customer service representatives to take telephone orders, has a Web site for Internet orders, processes mail orders, keeps its main inventory of products, and handles its general business and accounting functions. There are clothing factories in both Winnipeg and St. Cloud. The St. Cloud location also maintains customer service representatives for telephone orders. The company has hired you to help their IT Department implement new servers. Most of the IT Department members are located in Winnipeg, but

the St. Cloud site also has some IT staff. Both sites have computer resources and are networked via LANs, which are linked together through a WAN. IT operations go 24 hours a day, seven days a week, because the Customer Service Department takes telephone orders around the clock.

1. The Customer Service, Business, and Inventory Departments currently use separate customer service, business, and inventory programs on two large minicomputers, one located in Winnipeg and one in St. Cloud. Their plan is to purchase a new client/server system that will integrate all three areas into one software system. The new client/server system requires that they purchase three new Windows 2000 servers for the Winnipeg site and two servers for the St. Cloud site:
   - One server at each site will be used for application programs, customer service programs, and utility software.
   - One server at the Winnipeg site will house the main, large, integrated database requiring over 15 GB of disk space.
   - One server at each site will be used for generating business and inventory reports and to provide customer service information. These servers will contain a copy of the main integrated database at the Winnipeg site, each updated from the Winnipeg main database server four times each day.

   The IT Department has asked you to provide specifications for the servers at both sites. What questions would you ask the company to help you create specifications?
2. The Customer Service Department currently has a problem with slow access to their information on the minicomputers. How might you generate your specifications to help ensure fast access for them?
3. Another problem faced by Customer Service is that the minicomputers are aging, and a disk drive seems to fail about once every month or two. Usually this means that a computer is down for two to three hours while a new drive is installed and the data is recovered through a tape backup. Also, sometimes information from recently placed orders is lost. What type of fault tolerance is available through Windows 2000 Server that can help in this area should you consider as you create the server specifications?
4. What tape back up specifications do you recommend, particularly since you already know that the LANs in both locations are busy around the clock?
5. A Web server, which is not part of the client/server system, but which will feed information to that new system, is maintained by the Customer Service Department. The Web server is used to advertise over the Internet and to take orders; it has been in place for almost three years, and is a Pentium 133 computer with two mirrored drives. Growth in the accessing of the Web server has nearly quadrupled over the three years of its existence, and the company views it as an important competitive strategy. What specifications would you create to help them in their planning to upgrade that server?

6. The Business Department has 18 employees, 14 full-time and 4 part-time, who want to set up a new server from which to install Microsoft Office software and to centrally store Excel spreadsheets and Word documents. That server will also provide network print services for their department. They estimate that they will need about 8 GB of disk space now and that this will grow about 2 GB per year. What type of processor and disk storage do you recommend for this server?
7. What tape backup do you recommend for the Business Department's new server?

Optional Case Assignments for Teams

Team Case One

Mark Arnez wants to develop some in-house research about different manufacturers' options for hardware RAID that is compatible with Windows 2000 Server and the computers on which the operating system runs. Form a group to research as many hardware RAID options as you can find, for example through the Internet.

Team Case Two

Mark also wants some information about what computer is the fastest Web server available on the market right now. Form a team to research Web server test results from different publications and testing groups, and provide a report about the components used in the fastest Web server.